

INVESTIGATIONS OF NEW ENGLAND
MARINE ALGAE V.
THE ALGAL VEGETATION OF THE
HAMPTON-SEABROOK ESTUARY AND THE
OPEN COAST NEAR HAMPTON, NEW HAMPSHIRE¹

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Most botanical studies of New England salt marshes have been restricted to Massachusetts (e.g. Chapman, 1940; Drum and Webber, 1965; Webber, 1967, 1968; Webber and Wilce, 1971) and Connecticut (e.g. Miller and Egler, 1950) and little is known of these valuable wetlands in New Hampshire salt marches (i.e. Davis, 1956; Vagenas, 1969). Davis summarized the general ecology of the Crommet Creek Estuary, which is a small tributary of Great Bay, New Hampshire. Vagenas studied the seasonal occurrence, composition and zonation of algae and flowering plants at five locations in the Hampton-Seabrook salt marsh. For the past seven years we have conducted a variety of floristic and ecological studies of the marine algae on the open coast of New Hampshire and the Great Bay Estuary System (Mathieson, Hehre and Reynolds, in press; Mathieson, Reynolds and Hehre, in press; Hehre and Mathieson, 1970). The present investigation was initiated, at the request of Normandeau Associates Incorporated, in order to provide a broad "baseline" of information regarding the species composition, distribution and ecology of the benthonic marine algae of the Hampton-Seabrook Estuary and the adjacent open coast of New Hampshire (Fig. 1).

Collections and observations of marine algae were made at fifty-four stations in the Hampton-Seabrook Estuary and the adjacent open coast of New Hampshire (Fig. 1 and Table I) during the summer and fall of 1969. Prior to 1969 seasonal collections had been made on the open coast near

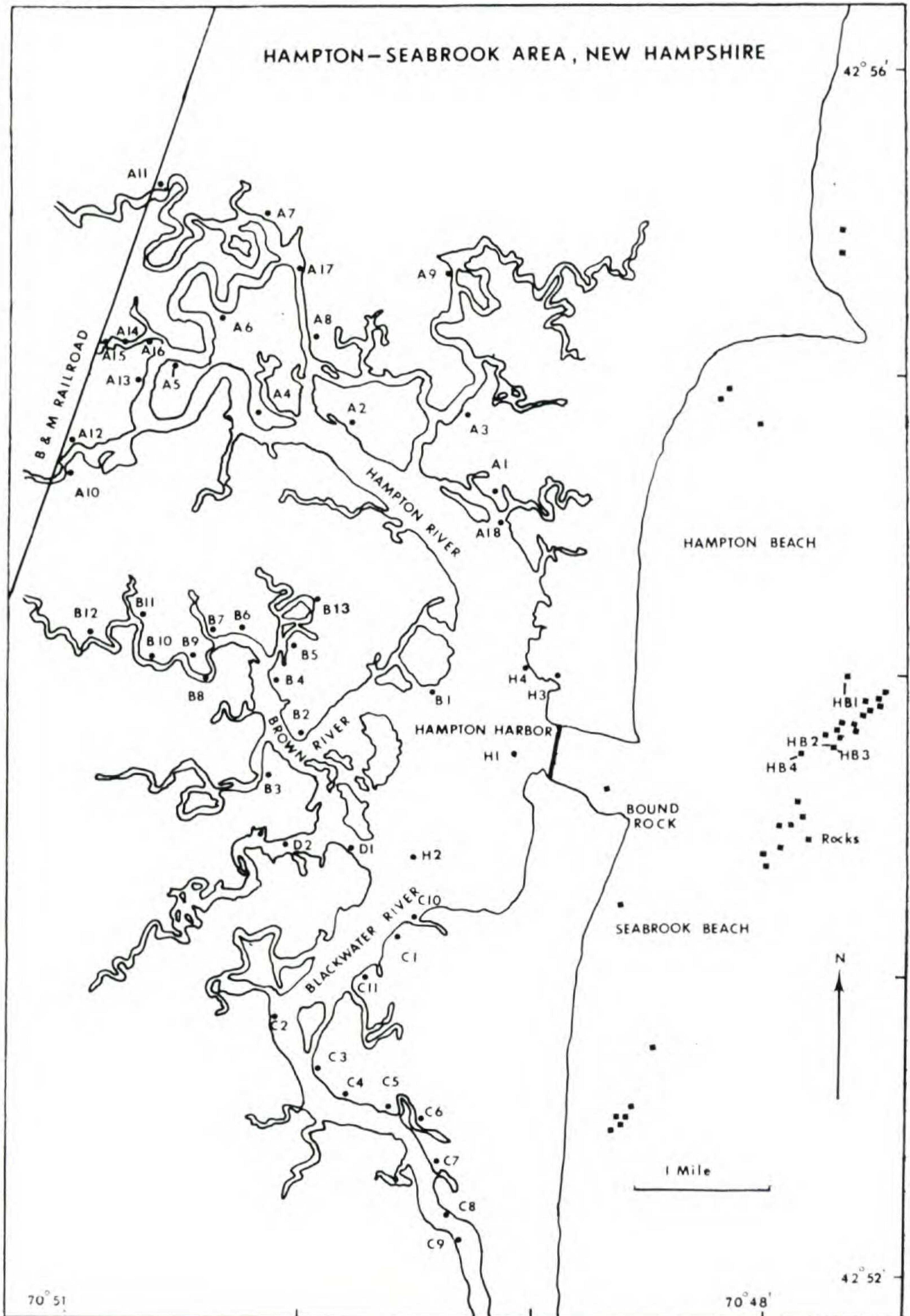
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Bound Rock, and limited collections were made in the estuary (during the fall and winter of 1966). The majority of the stations were established by Normandeau Associates in conjunction with their ecological survey of the estuary. The estuarine sites were identified by a pair of numbered stakes on opposite sides of the channel, and most of the collections were restricted to the side of the channel numbered on the map (Fig. 1) unless conspicuous differences were noted on the two sides. The locations were primarily shore sites, but a few offshore outcrops of rock were also studied (Fig. 1). An aluminum boat and outboard motor were used at most stations.

Representative samples of all conspicuous algal species were obtained at each station. Collections were made in the littoral (on foot) and sublittoral zones (by SCUBA). Extensive collections were made in the sublittoral zones on the open coast, but because of poor visibility, tidal currents and limited substrate for seaweed attachment, fewer sublittoral samples were available in the Estuary. A complete set of nearly 700 herbarium voucher specimens has been deposited in the Algal Herbarium of the University of New Hampshire (NHA). The nomenclature of the Second Revised British Checklist (Parke and Dixon, 1968) has been applied in most cases. The vertical distribution of the major algal components described in this article is given according to the biological classification of Lewis (1964).

A record of surface water salinity and temperature was made at most stations with a thermometer and a set of hydrometers. All of the salinity values were corrected to 15 C. Diurnal variations of temperature, salinity and current speed were recorded at one location (station C-9) during a twelve hour period. The current speed was recorded with a Little Captain boat speedometer (Swift Instrument Company of Boston, Massachusetts), which was modified with a six-foot well tube.

Table II summarizes the surface water temperature and salinity values recorded (1966-1969). The hydrographic conditions on the exposed open coast (Bound Rock) are



more uniform than in the Estuary — particularly at the headwaters of the tidal rivers. Gross fluctuations (both daily and seasonally) of temperature and salinity are evident at any estuarine location. Figures 2 and 3 summarize the results of a twelve hour study made at station C-9 on the Blackwater River. The location has a pronounced tidal current; thus, vertical mixing of the water column is evident and there is no stratification. Diurnal variations of temperature and salinity varied from 13.2 to 16.0 C and 11.5 to 14.5 ‰, respectively (Fig. 2). The maximum salinity and the minimum temperature were recorded at slack water. Diurnal variations of tidal currents are shown in Figure 3. The current varied from 0-4.8 knots.

A variety of substrates is evident at the stations. In general there is a gradient from sandy beaches with rock outcrops (i.e. Bound Rock which is on the exposed open coast) to sandy-muddy locations (i.e. at the mouth of the Estuary) to muddy and peat-like substrates (i.e. at the head of the tidal rivers). Only limited quantities of solid substrates (rock outcrops, boulders and breakwaters) are present in the Estuary.

There are pronounced seasonal fluctuations of sand levels on the open coast near Bound Rock, and the abrasive action of sand limits both the species diversity and biomass of algae. Even so there are many more species at Bound Rock than within the Estuary. The conspicuous vegetation at Bound Rock is composed of *Cladophora sericea*, *Enteromorpha intestinalis*, *Pseudendoclonium marinum*, *Ulva lactuca*, *Fucus distichus* ssp *distichus*, *F. vesiculosus*, *Petalonia fascia*, *Ralfsia verrucosa*, *Scytosiphon lomentaria*, *Ahnfeltia*

Figure 1. The Hampton-Seabrook Estuary lying between latitudes 42° 51' 30" to 42° 55' 55" north and longitudes 70° 49' 30" to 70° 51' 30" west within the townships of Hampton, Hampton Falls and Seabrook, New Hampshire. Note that all of the tidal waters enter and leave via the Hampton Harbor Inlet and that five rivers (Taylor, Hampton Falls, Hampton, Brown and Blackwater) as well as many smaller creeks and brooks are present within the Estuary. Dots with numbers show the stations.

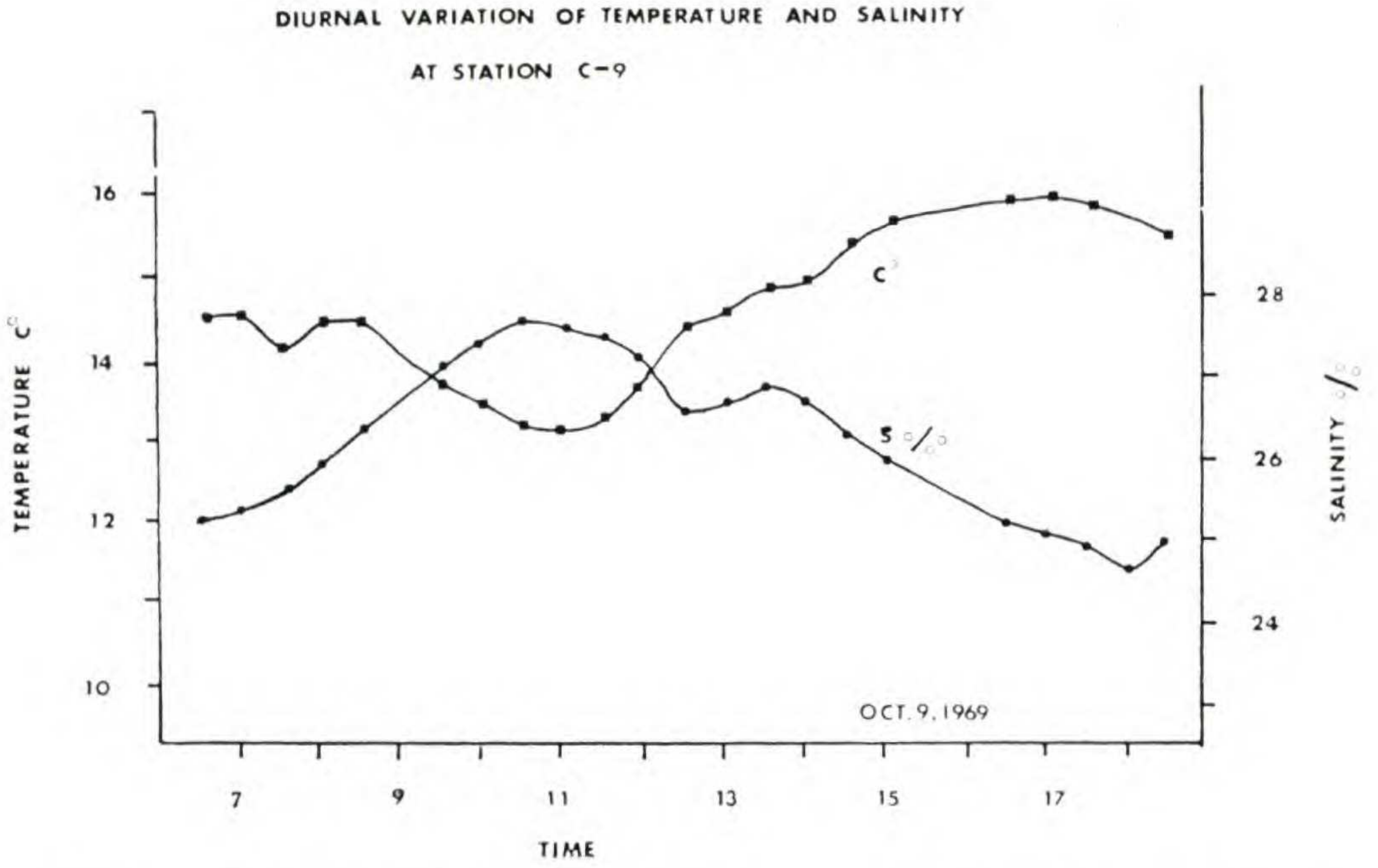


Figure 2. Diurnal variation of temperature and salinity at station C-9.

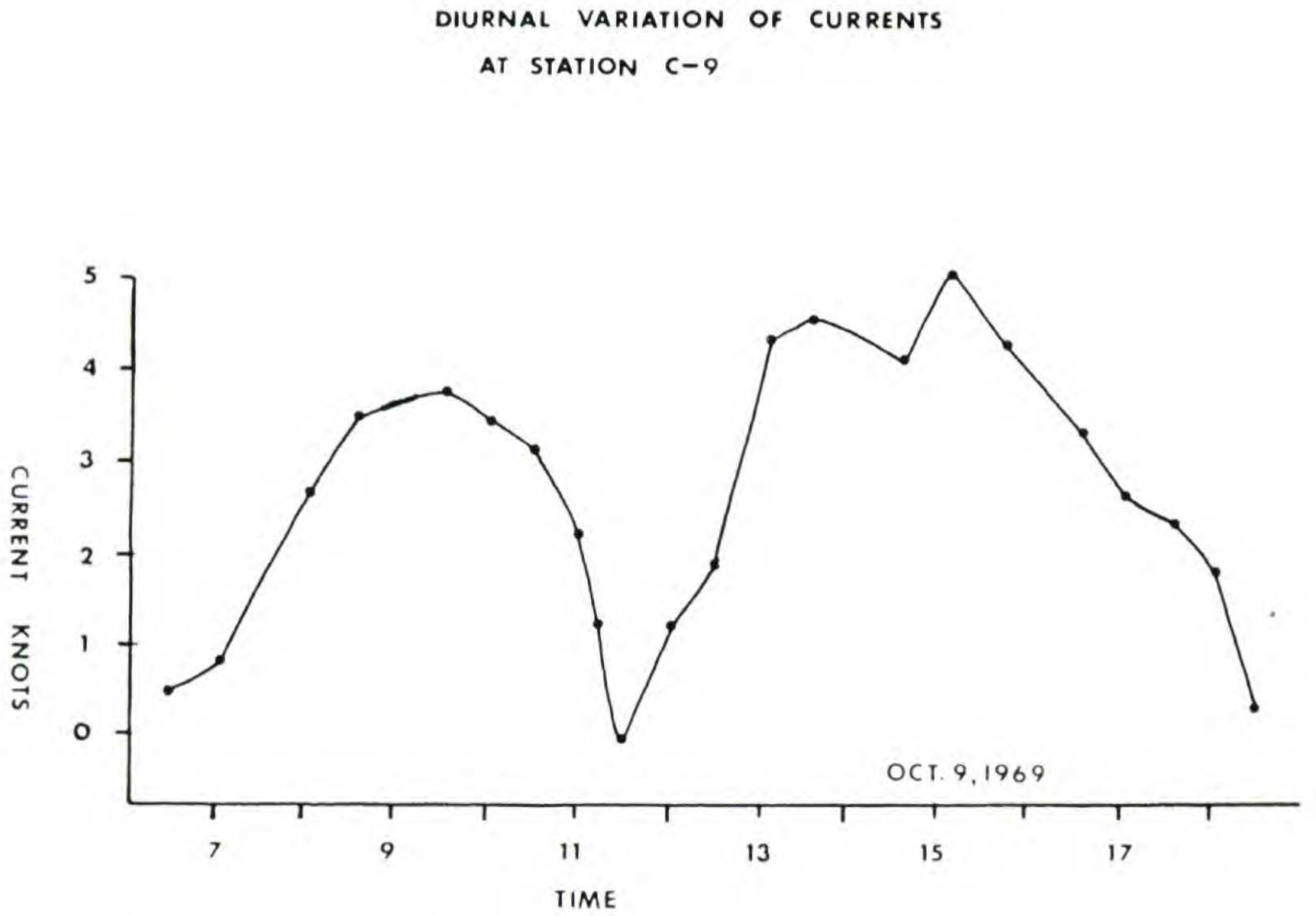


Figure 3. Diurnal variation of currents at station C-9.

plicata, *Chondrus crispus*, *Corallina officinalis*, *Hildenbrandia prototypus* and *Porphyra umbilicalis*. Some species (e.g. *Polyides rotundus* and *Ahnfeltia plicata*) are restricted to such sandy areas. Other plants which are not "sand loving" forms are often reduced in size, and they are only found in cracks and crevices. Several species are restricted to tide pools, which are somewhat protected from the fullest force of the sand and surf. *Fucus vesiculosus* dominates the eulittoral zone. *Ascophyllum nodosum* is conspicuously absent. Several common sublittoral species such as *Alaria esculenta*, *Laminaria saccharina*, *L. digitata* and *Desmarestia viridis* are rare at Bound Rock. However, they are present in greater abundance in the offshore rocks near Hampton Beach (station HB1-HB4 in Fig. 1).

A comparison of the common plants at Bound Rock with those of a "typical" estuarine site shows several differences. A variety of furoid (*Ascophyllum nodosum*, *A. nodosum* f. *scorpioides* and *Fucus vesiculosus* var. *spiralis*) green (*Cladophora sericea*, *Enteromorpha erecta*, *E. intestinalis*, *Monostroma oxyspermum*, *Percursaria percursa*, *Rhizoclonium riparium* and *Ulva lactuca*), blue green (*Lyngbya* spp, *Oscillatoria* spp and *Gomphosphaeria* spp.) and yellow green algae (*Vaucheria* sp.) dominate the littoral zone. In addition *Spartina alterniflora*, *S. patens* and *Distichlis spicata* are abundant in the upper portion of the shore.

Results

A total of 118 taxa of benthonic marine algae was collected from the fifty-four stations, including 30 Chlorophyceae, 35 Phaeophyceae and 53 Rhodophyceae. A detailed examination of the Cyanophyceae, Bacillariophyceae and Xanthophyceae was beyond the scope of the present investigation. Table III summarizes the number of seaweed taxa found at each of the stations. The largest number of taxa was found at Bound Rock with fewer towards the head of the Estuary. Gross fluctuations of species numbers were recorded at different locations within the Estuary.

The following catalogue of Species includes some synony-

my, notes on collection sites and habitats and noteworthy taxonomic features. The occurrence of each species is designated numerically as follows according to its habitat (Hehre and Mathieson, 1970; Mathieson, Hehre and Reynolds, in press; Mathieson, Reynolds and Hehre, in press):

- #1 Coastal — restricted to the open coast
- #2 Estuarine — restricted to the estuarine environment
- #3 Cosmopolitan — present in both estuarine and open coastal environments.

Several of the cosmopolitan species may not occur in both habitats in the Hampton-Seabrook area, but they have been recorded from either the Great Bay Estuary or the open coast adjacent to Bound Rock.

List of Species

Chlorophyceae:

Blidingia marginata (J. Agardh) P. Dangeard:

equals *Enteromorpha marginata* J. Agardh in Taylor, 1957)

Found once on rocks in the lower eulittoral zone at Bound Rock. #3

Blidingia minima (Nägeli ex Kützing) Kylin:

(equals *Enteromorpha minima* Nägeli in Taylor, 1957)

Found once in the estuary (B9) on a muddy bank in the upper littoral zone. Abundant on the exposed open coast (Bound Rock) where it forms fringe zones. #3

Bryopsis plumosa (Hudson) C. Agardh

Locally abundant in the estuary (A3, A5, A9, A15, A17, B1, B2, B4 to B6, B8, and H3) on muddy surfaces in the sublittoral and lower eulittoral zones. Not found on the open coast. #2

Chaetomorpha aerea (Dillwyn) Kützing:

Collected three times from the lower eulittoral (in tide pools) at Bound Rock. #1

Chaetomorpha linum (O. F. Muller) Kützing:

(including *Chaetomorpha atrovirens* Taylor, in Taylor, 1957)

According to our interpretation *C. atrovirens* and *C. linum* are not distinct for there is a continuous gradient of size and color between the two. *Chaetomorpha linum* is the older name and it should be retained. The plant is common as an entangled mass amongst various algae in the lower eulittoral and sublittoral zones of the estuary (A2, A11, A18, B1, B2, B4 to B6, B9, B10, B12, C1, C2, C6, C7, and C9) and the exposed open coast (Bound Rock, HB1 and HB4). #3

Chaetomorpha melagonium (Weber et Mohr) Kützing:
Occasional on rocks in the lower eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1 and HB4). #3

Cladophora sericea (Hudson) Kützing sensu van den Hoek,
1963:

Locally abundant in high tide pools in the estuary (A6, A7, A9, A10, B3, B7, B10, B12, C3 to C5, and H3) and on the exposed open coast (Bound Rock). #3

Codiolum pusillum (Lyngbye) Kjellman in Foslie:

Locally abundant on rocks in the upper littoral zone of the exposed open coast (Bound Rock). Often mixed with *Bangia fuscopurpurea* and various blue green algae. It may be the sporophyte stage of one or more local species of *Urospora* (Scagel, 1966). #1

Enteromorpha compressa (L.) Greville:

Found once on rocks in the lower eulittoral zone at Bound Rock. #3

Enteromorpha erecta (Lyngbye) J. Agardh:

Abundant on muddy surfaces of the eulittoral zone throughout the estuary (A1 to A9, A13, A14, A16, A17, B1 to B7, B9, B13, C1 to C6, H1 and H3); occasionally present as an epiphyte on furoid algae and *Spartina alterniflora*. Uncommon on the exposed open coast (Bound Rock). #3

Enteromorpha intestinalis (L.) Link:

Common on rocks and muddy surfaces of the eulittoral zone throughout the estuary (A1, A2, A4, A6 to A10, A13, A17, B1 to B5, B8, C1, C3, C5 to C7, C9, and H3) and on the open coast (Bound Rock). #3

Enteromorpha linza (L.) J. Agardh:

Found sporadically in the estuary (C9 and H1) and the exposed open coast (Bound Rock and HB1); present on mud, rocks and as an epiphyte in the lower eulittoral and upper sublittoral zones. #3

Enteromorpha plumosa Kützing:

Found twice in the estuary (A18 and B12) on muddy surfaces in the lower eulittoral zone. #3

Enteromorpha prolifera (O. F. Müller) J. Agardh:

Infrequent in the estuary (B2, C2, C3, C5, C6 and C11); present on muddy surfaces of the eulittoral zone. Mixed with *Enteromorpha erecta* but never occurring as abundantly. #3

Monostroma fuscum (Postels et Ruprecht) Wittrock:

Found sporadically throughout the estuary (A15, B2, B4, B6, B8, C1 and C3) on mud and rocks in the lower eulittoral and sublittoral zones. Abundant in localized areas on the exposed open coast (Bound Rock and HB4), and with the same vertical distribution. #3

Monostroma grevillei (Thuret) Wittrock:

Infrequent on rocks in the mid and lower eulittoral zones of the estuary (A5, A15, B6 and B10). Abundant on the exposed open coast (Bound Rock) and with the same vertical distribution. #3

Monostroma leptodermum Kjellman:

Found once adrift at A3. #3

**Monostroma oxyspermum* (Kützing) Doty:

Locally abundant throughout the estuary (A2 to A4, A9, B1, B4, B6, B8, C1, C2, and C4 to C7) — particularly in areas of low salinity. It forms a distinct band on high vertical (muddy) banks and occasionally occurs as an epiphyte on *Spartina alterniflora* and other vascular plants. #2

Monostroma pulchrum Farlow:

Common (during the summer) on rocks and on various algae in the lower eulittoral and sublittoral zones of the exposed open coast (Bound Rock). #3

*Within range but not previously recorded for New Hampshire.

Percursaria percursa (C. Agardh) Rosenvinge:

Locally abundant in the estuary (A1, A2, A16, B1, B3, B6, B7, and C3 to C5) as free-floating masses in tide pools and attached to muddy surfaces in the upper eulittoral zone. Often mixed with *Rhizoclonium riparium* and *Cladophora sericea*. #3

Pseudendoclonium marinum (Reinke) Aleem et Schulz:

(equals *Protoderma marinum* Reinke in Taylor, 1957)

Abundant on rocks from the mid eulittoral to the sublittoral zones on the exposed open coast (Bound Rock); found once in the estuary (A11). #3

Rhizoclonium riparium (Roth) Harvey:

Abundant throughout the estuary (A1 to A5, A7 to A9, A15, B1 to B4, B6, B8 to B10, B11 to B13, C1 to C6, C8, C10, C11, and H3) as free floating masses in tide pools and attached to muddy surfaces in the upper littoral zone. Often mixed with *Cladophora sericea* and *Percursaria percursa*. #3

Rhizoclonium tortuosum Kützing:

Abundant during the summer on the exposed open coast (Bound Rock); found once in the estuary (C9). Present as entangled masses amongst various algae (particularly *Chondrus crispus* and *Gigartina stellata*) in the lower eulittoral and sublittoral zones. #3

Spongomorpha arcta (Dillwyn) Kützing:

Abundant on rocks (rarely as an epiphyte) in the mid-lower eulittoral zones of the exposed open coast (Bound Rock); most conspicuous in the late winter and spring.

#3

Spongomorpha spinescens Kützing:

Abundant on rocks in the mid to lower eulittoral zones of the exposed open coast (Bound Rock); most conspicuous in the spring and summer. #3

Ulothrix flacca (Dillwyn) Thuret in Le Jolis:

Locally abundant (during winter and spring) on rocks in the upper littoral zone of the exposed open coast (Bound Rock). #3

Ulva lactuca L:

Ubiquitous throughout the estuary (being found at all stations except A6, A11, A15, A16, C8, D2, D3, H2, and H4) on mud and any solid substrates in the lower eulittoral and sublittoral zones. Present on the exposed open coast (Bound Rock and HB2 and HB4) but not as abundant as in the estuary. #3

Urospora collabens (C. Agardh) Holmes et Batters:

Locally abundant (particularly during the winter and spring) on rocks in the upper littoral zone at Bound Rock. #3

Urospora penicilliformis (Roth) Areschoug:

The abundance and distribution (both seasonal and vertical) of this species is essentially similar to that of *U. collabens* — except that it tends to appear later than *U. collabens*. #3

Urospora speciosa (Carmichael ex Harvey in Hooker) Leblond et Hamel:

Occasional (particularly during the winter and spring) on rocks in the upper littoral zone at Bound Rock. #1

Phaeophyceae:

Agarum cribrosum (Mertens) Bory:

Common on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB1, HB3, and HB4); not found in the estuary. #1

Alaria esculenta (L.) Greville:

Locally abundant on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB2 and HB3); not found in the estuary. #1

Ascophyllum nodosum (L.) Le Jolis:

Common throughout the estuary (A2, A4, A11, A13, A14, A17, A18, B1, B2, B9, B10, C1 to C4, C10 and C11 and H3) on any solid substrate from the upper sublittoral to the mid eulittoral zones. It is a rare plant on the exposed open coast at Bound Rock. #3

Ascophyllum nodosum (L.) Le Jolis f. *scorpioides* (Hornemann) Reinke:

Common on high muddy banks throughout the estuary (A1 to A3, A5 to A7, A12 to A14, A17, B1 to B3, B5, B6, B8, B9, B13, C1 to C3, C5, C6, C11, D2 and D3); entangled amongst *Spartina alterniflora* and other vascular plants. #2

Chorda filum (L) Stackhouse:

Found once on pier pilings in the estuary (H3); another time on rocks and shells on the exposed open coast (Bound Rock). In both cases the plants were present in the sublittoral zone. #3

Chorda tomentosa Lyngbye:

Locally abundant (during the summer) on scattered rocks in the sublittoral zone of the exposed open coast (Bound Rock and HB3). #3

Chordaria flagelliformis (O. F. Müller) C. Agardh:

Found twice in the estuary (H1 and H3); in both cases it was growing on pier pilings in the lower eulittoral — sublittoral zones. The plant is common (during the summer) on the exposed open coast (Bound Rock and HB2) and has the same vertical distribution as in the estuary. #3

Desmarestia aculeata (L.) Lamouroux:

Common on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB2 to HB4). #1

Desmarestia viridis (O. F. Müller) Lamouroux:

Occasional on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB1, HB3 and HB4). #1

Dictyosiphon foeniculaceus (Hudson) Greville:

Found once on mud covered rocks in the lower eulittoral zone of the estuary (C5). #3

Ectocarpus confervoides (Roth) Le Jolis:

(equals *E. siliculosus* (Dillwyn) Lyngbye in Parke and Dixon, 1968)

Occasional on rocks and larger algae in the eulittoral and sublittoral zones of the estuary (A14, A17, B9, C9 to C11 and H1) and the exposed open coast (Bound Rock, HB1 to HB4). The estuarine plants were more robust in stature than the plants from the open coast. #3

Ectocarpus siliculosus (Dillwyn) Lyngbye:

Found once as an epiphyte on *Spartina alterniflora* in the upper littoral zone of the estuary (C5). #3

Elachista fucicola (Vellely) Areschoug:

An occasional epiphyte on *Ascophyllum nodosum* and *Fucus vesiculosus* var *spiralis* in the estuary (A1, B12, C1, C3, C5 and H3); very common on *Fucus vesiculosus* on the exposed open coast (Bound Rock and HB2). #3

Fucus distichus (L.) emend Powell subsp. *distichus* Powell:
Locally abundant in high tide pools of the exposed open coast (Bound Rock). #1

Fucus distichus (L.) emend Powell subsp. *edentatus* (De la Pylaie) Powell:

Common on rocks in the lower eulittoral — sublittoral zones of the exposed open coast (Bound Rock and HB2). Found once in a similar habitat near the mouth of the estuary (H1). #3

Fucus distichus (L.) emend. Powell subsp. *evanescens* (C. Agardh) Powell:

Locally abundant on rocks in the lower eulittoral — sublittoral zones of the exposed open coast (Bound Rock). #3

Fucus vesiculosus L:

Abundant on semi-exposed rocks from the mid to the lower eulittoral at Bound Rock. #3

Fucus vesiculosus L. var *spiralis* Farlow:

Ubiquitous throughout the estuary (at all stations except A12, A15, A16, C8, H1, H2 and H4) on mud, rocks, shells and any other solid substrates in the mid to the upper eulittoral zone. It is one of the most conspicuous species on the upper banks of the salt marshes, where it is associated with *Ascophyllum nodosum* f. *scorpioides*, *Spartina alterniflora* and various other vascular plants. #2

Giffordia granulosa (J. E. Smith) Hamel:

Found once in the estuary (A7) on mud-covered rocks in the lower eulittoral zone. #2

Laminaria digitata (Hudson) Lamouroux:

Present on rocky substrate in the sublittoral zone of the exposed open coast (Bound Rock, HB1, HB3 and HB4) and at the mouth of the estuary (H1). Each specimen had a consistent +- anatomy (i.e. mucilage ducts are present in the blade and absent from the stipe, Wilce, 1965). #3

Laminaria saccharina (L.) Lamouroux sensu Wilce, 1965:

Its distribution was essentially similar to that of *L. digitata* except that it was found at one other coastal (HB2) and estuarine location (A18). All of the specimens were the -- ecotype of Wilce, 1965 (i.e. *L. agardhii* Kjellman in Taylor, 1957). #3

Leathesia difformis (L.) Areschoug:

A common epiphyte (during the summer) on *Chondrus crispus* and other algae in the lower eulittoral-upper sublittoral zones of the exposed open coast (Bound Rock and HB2). #1

Petalonia fascia (O. F. Müller) Kuntze:

Common throughout the estuary (A4, A5, A7, A9, A14, A15, A17, B2, B4, B6, B10, B13, C2, C6, C11, D2 and D3) and on the exposed open coast (Bound Rock). It is present in the eulittoral zone on rocks (often in tide pools), mud, and occasionally as an epiphyte on large algae. #3

Pilaiella littoralis (L.) Kjellman:

Common on rocks and as an epiphyte on *Fucus vesiculosus* in the mid-lower eulittoral zones of the exposed open coast (Bound Rock). Occasionally present in the estuary (C1, C5 and C6) and with the same vertical distribution. #3

**Pseudolithoderma extensum* (Crouan frat.) S. Lund:

(equals *Lithoderma extensum* (Crouan) Hamel in Taylor, 1957)

Occasional on sublittoral stones and boulders of the exposed open coast (HB2 and HB4). #1

Ralfsia borneti Kuckuck:

Occasional on stones and boulders in the lower eulittoral - sublittoral zones of the estuary (A8, A10, B10, B11, and C1). According to Edelstein, Chen and McLachlan (1970)

R. borneti is a stage in the life history of *Petalonia fascia*, and it is not a valid taxa. #3

Ralfsia clavata (Harvey in Hooker) Crouan frat.:

Found once in the estuary (A-8) on mud covered rocks in the lower eulittoral zone. It is also described (Edelstein, Chen and McLachlan, 1970) as a stage in the life history of *Petalonia fascia*. #3

Ralfsia fungiformis (Gunner) Setchell et Gardner:

Found once on rocks in the sublittoral zone of the exposed open coast (HB4). #1

Ralfsia verrucosa (Areschoug) J. Agardh:

Found twice on rocks and shells in the upper sublittoral and eulittoral zones of the estuary (B3 and C1). Abundant in the same zones on the exposed open coast (Bound Rock). #3

Saccorhiza dermatodea (De la Pylaie) J. Agardh:

Occasional on rocks in the sublittoral zone of the exposed open coast (HB1 and HB3). #1

Scytosiphon lomentaria (Lyngbye) Link:

Present on rocks (often in tide pools), mussels shells, mud and occasionally epiphytic on various plants in the eulittoral zone of the estuary (A5, A14, A15, A17, B1, B2, B4, B10, C9, C11 and D3) and the exposed open coast (Bound Rock). #3

***Sorapion kjellmanii* (Wille) Rosenvinge:

Found once on rocks in the sublittoral zone of the exposed open coast (HB2). #1

***Sphacelaria plumosa* Lyngbye:

(equals *Chaetopteris plumosa* (Lyngbye) Kützing in Taylor, 1957)

Occasional on sand covered rocks in the mid-lower sublittoral zone of the exposed open coast (HB1). #1

Sphacelaria radicans (Dillwyn) C. Agardh:

Occasional on muddy or sandy surfaces in the mid-lower eulittoral zone of the estuary (A9, B1 and B10); also

**Range extension and a new record for New Hampshire.

present on sand covered rocks in the sublittoral zone of the exposed open coast (HB1, HB3 and HB4). #3

Spongonema tomentosum (Hudson) Kützing:

(equals *Ectocarpus tomentosus* (Hudson) Lyngbye in Taylor, 1957)

Found once as an epiphyte on *Laminaria saccharina* in the sublittoral zone of the exposed open coast (HB3). #1

Rhodophyceae:

Ahnfeltia plicata (Hudson) Fries:

Locally abundant on sand-covered rocks and boulders in the lower eulittoral – sublittoral zones of the exposed open coast (Bound Rock, HB1, HB2 and HB4). #3

Antithamnion floccosum (O. F. Müller) Kleen:

Found once on sand covered rocks in the sublittoral zone of the exposed open coast (HB3). #3

Audouinella membranaceae (Magnus) Papenfuss:

Epiphytic on species of *Sertularia* which in turn may be epiphytic (commonly on furoid algae) or saxicolous in the eulittoral zone of the exposed open coast (Bound Rock). #3

**Asterocytis ramosa* (Thwaites in Harvey)

Gobi ex Schmitz:

Found once as an epiphyte on *Cladophora sericea* in a high marshy tide pool (C4). Growing in association with *Percursaria percursa* and various blue green algae. #2

Bangia ciliaris Carmichael:

Found once as an epiphyte on *Cladophora sericea* in a high marshy tide pool (C5) in the estuary. #3

Bangia fuscopurpurea (Dillwyn) Lyngbye:

Abundant (particularly during the winter and spring) on rocks in the upper littoral zone of the exposed open coast (Bound Rock). #3

Callithamnion baileyi Harvey:

Found once in the estuary (H3) on a styrofoam float. #3

Callithamnion corymbosum (J. E. Smith) C. Agardh:

Found once in the estuary (A17) on rocks in the upper sublittoral zone. #2

Ceramium rubrum (Hudson) C. Agardh:

Present on rocks and epiphytic on large macroscopic algae in the lower eulittoral and sublittoral zones. Occasional within the estuary (B1 to B3, B7, C2, C5, and H3), but more abundant on the exposed open coast (Bound Rock, HB1 to HB4). #3

Ceramium strictum Harvey:

Abundant throughout the estuary (A1 to A4, A7, A8, A10, A12, A17, B1 to B6, B9, C1, C3 to C7, C11 and H1) on muddy surfaces in the lower eulittoral – sublittoral zones. Uncommon on the exposed open coast (Bound Rock). #3

Chondrus crispus Stackhouse:

Common throughout the estuary (A1 to A3, A5, A9 to A15, A17, A18, B2, B4 to B6, B8 to B11, C1, C9, C11, D3 and H1) and the exposed open coast (Bound Rock, HB2 to HB4); present on any solid substrate in the lower eulittoral and sublittoral zones. The stature of the estuarine plants is much larger than the plants from the open coast. #3

Clathromorphum circumscriptum (Strömfelt) Foslie:

(equals *Phymatolithon compactum* (Kjellman) Foslie in Taylor, 1957)

Abundant on rocks and shells in the lower eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1 to HB4). Found once in the estuary (A10) on a subtidal population of mussels. #3

Corallina officinalis L.:

Locally abundant on rocks and boulders (often in tide pools) in the eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1 to HB4). #1

Cystoclonium purpureum (Hudson) Batters var. *cirrhosum* Harvey:

Present on rocks and as an epiphyte on larger algae in the sublittoral zone of the exposed open coast (Bound Rock, HB1 to HB4). #3

Dermatolithon pustulatum (Lamouroux) Foslie:

(equals *Lithophyllum pustulatum* (Lamouroux) Foslie in Taylor, 1957)

An occasional epiphyte on various algae (particularly *Chondrus crispus* and *Gigartina stellata*) in the lower eulittoral-sublittoral zones of the exposed open coast (Bound Rock, HB2 and HB4). #3

Dumontia incrassata (O. F. Müller) Lamouroux:

Abundant on rocks in the mid and lower eulittoral zones of the exposed coast (Bound Rock). Occasional throughout the estuary (A5, A14, A15, A17, A18, B6, B10, and D3) and with the same vertical distribution as on the open coast. #3

Euthora cristata (C. Agardh) J. Agardh:

Present on rocks and occasionally epiphytic on various plants (e.g. *Phyllophora* spp.) in the sublittoral zone of the exposed open coast (Bound Rock, HB1, HB3 and HB4). #1

Gigartina stellata (Stackhouse) Batters:

On rocks in the lower eulittoral and sublittoral fringe zones of the exposed open coast (Bound Rock). #3

Gloiosiphonia capillaris (Hudson) Carmichael *ex* Berkeley: Found twice on rocks in the sublittoral zone of the exposed open coast (HB1 and HB4). #3

Hildenbrandia prototypus Nardo:

Common on rocks in the eulittoral and sublittoral zones of the exposed open coast (Bound Rock and HB2). Less common in the estuary (A8, A10, A11 and B10) but with the same vertical distribution. #3

Kylinia secundata (Lyngbye) Papenfuss:

A common epiphyte on various algae in the eulittoral zone of the exposed open coast (Bound Rock). #3

Lithophyllum corallinae (Crouan frat.) Heydrich:

Found once in the sublittoral zone of the exposed open coast (HB4); a specific epiphyte on *Corallina officinalis*. #1

Lithothamnium glaciale Kjellman:

Common on shells and rocks (often in tide pools) in the

lower eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1 to HB4). #1

Melobesia lejolisii Rosanoff:

(equals *Fosliella lejolisii* (Rosanoff) Howe in Taylor, 1957)

An occasional epiphyte on *Phyllophora* spp. in the sublittoral zone of the exposed open coast (Bound Rock and HB3). #3

Membranoptera alata (Hudson) Stackhouse:

A common epiphyte on various algae (occasionally on rock) in the sublittoral zone of the exposed open coast (Bound Rock, HB1, HB3 and HB4). #1

Nemalion helminthoides (Vellely in Withering) Batters:

Uncommon on rocks in the lower eulittoral zone of the exposed open coast (Bound Rock). #1

Petrocelis middendorfi (Ruprecht) Kjellman:

Present on rocks and shells in the sublittoral zone of the exposed open coast (HB2 and HB4). #3

Peyssonelia rosenvingii (Schmity in Rosenvinge):

Occasional on rocks in the sublittoral zone of the exposed open coast (HB1 and HB4). #1

Phycodryis rubens (L.) Batters:

Common on rocks and as an epiphyte on various algae in the lowest eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1, HB3 and HB4) and at the mouth of the estuary (H1). #3

Phyllophora brodiaei (Turner) Endlich:

Common on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB1 to HB4). #1

Phyllophora membranifolia (Goodenough *et* Woodward)

J. Agardh:

The vertical and horizontal distribution of *P. membranifolia* is essentially similar to that of *P. brodiaei*. It was found at stations HB2, HB3 and Bound Rock. #3

**Phymatolithon laevigatum* (Foslie) Foslie:

Present on rocks and shells in the sublittoral zone of the exposed open coast (HB2 to HB4). #1

Phymatolithon lenormandi (Areschoug) Adey:

Present on rocks in the sublittoral zone of the exposed open coast (HB4). #3

Plumaria elegans (Bonnemaison) Schmitz:

Common on vertical rock faces under overhanging fucoids in the lower eulittoral zone of the exposed open coast (Bound Rock). It was found once in the estuary (A14) with the same vertical distribution. #3

Polyides rotundus (Hudson) Greville:

Occasional on sand covered rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB2 to HB4). #3

Polysiphonia denudata (Dillwyn) Greville *ex* Harvey in Hooker:

Found twice in the estuary (B6 and B10) on muddy surfaces in the sublittoral zone. #3

Polysiphonia elongata (Hudson) Sprengel:

Found twice in the sublittoral zone of the estuary (A7 and H3). #2

Polysiphonia fibrillosa (Dillwyn) Sprengel:

Common throughout the estuary (A1, A2, A4, A10, B2 to B6, C2, C4 to C6, C9 and H3) on muddy surfaces in the lower eulittoral and sublittoral zones. #2

Polysiphonia lanosa (L.) Tandy:

Hemiparasitic on *Ascophyllum nodosum* on the open coast (Bound Rock) and at the mouth of the estuary (A2 and A4). #3

Polysiphonia nigra (Hudson) Batters:

Present on rocks in the lower eulittoral-sublittoral zones of the estuary (A15, B2, B3, B6, B7 and H3) and the exposed open coast (Bound Rock). #3

Polysiphonia nigrescens (Hudson) Greville:

On rocks and shells in the lower eulittoral and sublittoral zones of the estuary (A4, A7, A11, A12, A15, B2, B4, B5, B10, C1, C2, C5, H1 and H3) and the exposed open coast (HB1 and HB4). #3

Polysiphonia novae-angliae Taylor:

Present on rocks in the sublittoral zone of the exposed open coast (Bound Rock, HB1 and HB2). #3

Polysiphonia subtilissima Montagne:

Found once in the estuary (A12); growing on mud in the lower eulittoral zone. #1

Polysiphonia urceolata (Lightfoot *ex* Dillwyn) Greville:

Common on rocks in the lower eulittoral and sublittoral zones of the exposed open coast (Bound Rock, HB1 to HB4). Found once in the estuary at (B6) with the same vertical distribution. #3

Porphyra miniata (C. Agardh) C. Agardh:

Common (particularly during the summer) on rocks and epiphytic on various plants in the upper sublittoral zone of the exposed open coast (HB1 to HB4). #3

Porphyra umbilicalis (L.) J. Agardh:

Common on rocks, mud and on various algae in the eulittoral zone of the estuary (A1, A3 to A5, A8, A12, A14, A17, C3, C5, C6, C9, H1 and H3) and the exposed open coast (Bound Rock). #3 The forma *epiphytica* Collins was only found at Bound Rock. #3

Ptilota serrata Kützing:

Present on rocks and epiphytic on various algae in the sublittoral zone of the exposed open coast (Bound Rock, HB1 and HB3). #1

Rhodochorton purpureum (Lightfoot) Rosenvinge:

Present on vertical rock faces under overhanging fucoids in the midlower eulittoral zone of the exposed open coast (Bound Rock). #3

**Rhodophysema elegans* (Crouan frat. *ex* J. Agardh)

Dixon: (equals *Rhododermis elegans* Crouan in Taylor, 1957)

Occasional on rocks and shells in the sublittoral zone of the exposed open coast (HB2 and HB4). #1

Rhodomela confervoides (Hudson) Silva:

Locally abundant on sand-covered rocks in the lower eulit-

toral and sublittoral zones of the exposed open coast (Bound Rock, HB1 and HB3). #1

Rhodophyllis dichotoma (Lepeschkin) Gobi:

Found once adrift at Bound Rock. #1

Rhodymenia palmata (L.) Greville:

Relatively common on rocks and various algae (particularly *Laminaria* spp.) in the sublittoral zone of the exposed open coast (Bound Rock, HB1 to HB4) and the mouth of the estuary (H1). #3

DISCUSSION

Eight of the taxa of marine algae recorded in the present study represent new records for the state of New Hampshire (*Monostroma oxyspermum*, *Asterocytis ramosa*, *Phymatolithon laevigatum*, *Polysiphonia fibrillosa*, *Rhodophysema elegans*, *Pseudolithoderma extensum*, *Sorapion kjellmanii* and *Sphacelaria plumosa*). *Sorapion kjellmanii* and *Sphacelaria plumosa* also represent extensions of known distributional range on the northeast coast of North America, for they were both previously recorded from Ellesmere Island to Nova Scotia (as summarized in Taylor, 1957 and Cardinal, 1968). It should be noted that both species were collected in the mid-lower sublittoral zones of the open coast.

The primary factors restricting the growth and distribution of seaweeds in the Hampton-Seabrook Estuary are a lack of stable substrate and adverse hydrographic conditions. As a consequence gross fluctuations of species numbers occurred at different locations, and a gradual reduction in species diversity and biomass was evident from the open coast to the head of the estuary. Green algae showed the widest distribution throughout the estuary, for they grew on a variety of substrates and in a wide range of temperatures and salinities.

A greater diversity and biomass of seaweeds were recorded in the Great Bay Estuary complex (Mathieson, Reynolds and Hehre, in press) than in the Hampton-

Seabrook Estuary. Thus, 98 taxa of algae were found in the former area, while only 57 were found in the latter. The variety of species found in the estuarine environments of Great Bay is primarily due to its large size (over 15,000 acres of tidewater) and its greater variety of habitats (particularly tidal rapids) and substrates. Peak populations of seaweeds were found at Dover Point and Adams Point in the Great Bay System (Mathieson, Reynolds and Hehre, in press). Both of the sites are exposed to strong tidal currents and their floras are "open coastal" in nature. More than half of the 76 cosmopolitan species found in the Great Bay area were either restricted to the two tidal rapid sites or they did not extend inland beyond Dover Point or Adams Point. Only one major tidal rapid was observed in the Hampton-Seabrook area (station C-9), and it was so shaded that few algae grew there. The discrepancy in species numbers between the two estuaries is primarily accounted for by the cosmopolitan component of Great Bay.

All of the species found in the Hampton-Seabrook Estuary, except *Monostroma oxyspermum*, *Chorda filum*, *Dictyosiphon foeniculaceus*, *Elachista fucicola*, *Ralfsia borneti*, *R. clavata*, *Sphacelaria radicans*, *Asterocytis ramosa*, *Plumaria elegans* and *Polysiphonia fibrillosa*, were also found in the Great Bay area. The occurrence of *P. elegans* and *S. radicans* in estuarine waters was particularly striking, for both of the species are most abundant on the open coast.

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Table I

Stations

- A- 1 At the mouth of the first major tributary SE of Tide Mill Creek on the Hampton River, Hampton Falls, Hampton, N. H.* (1.3 miles inland)
- A- 2 The northeast portion of an "island" formed at the mouth of the Taylor River, Blind Creek and the upper part of the Hampton River, Hampton Falls, Hampton, N. H. (1.91 miles inland)
- A- 3 Approximately 1500 feet NE of the mouth of Tide Mill Creek and the Hampton River, Hampton, N. H. (1.3 miles inland)
- A- 4 Approximately 1800 feet NW of Station A-2 on the Hampton River, Hampton-Hampton Falls, N. H. (2.3 miles inland)
- A- 5 Opposite a small brook, which empties into the first tributary above the mouth of the Hampton Falls River, Hampton, N. H. (3.3 miles inland)
- A- 6 At the junction of the first oxbow NE of station A-5 on the Taylor River, Hampton, N. H. (3.2 miles inland)
- A- 7 Hampton Landing on the Taylor River, Hampton, N. H. (3.1 miles inland)
- A- 8 At the mouth of Nudds Canal and Blind Creek, Hampton, N. H. (2.31 miles inland)
- A- 9 Tide Mill Creek, by the route 101 bridge, Hampton, N. H. (2.56 miles inland)
- A-10 Hampton Falls River south of Depot Avenue and near the Boston and Maine Railroad bridge, Hampton Falls, N. H. (5.2 miles inland)
- A-11 Approximately 2000 feet SW of the Boston and Maine "sub-station" which is between Lafayette and Landing Roads. Station A-11 is adjacent to the B & M railroad tracks, and on the Taylor River, Hampton, N. H. (4.4 miles inland)
- A-12 End of Depot Avenue on the Hampton Falls River, Hampton Falls, N. H. (5.0 miles inland)
- A-13 Middle of the southernmost oxbow near the mouth of the Taylor River and the Hampton Town Line, Hampton, N. H. (3.0 miles inland)
- A-14 A bend in the first tributary above (north) the Hampton Falls River where the river crosses the railroad tracks, Hampton, N. H. (3.7 miles inland)
- A-15 Same as A-14, except the land side of the railroad tracks, rather than the harbor side as A-13, Hampton, N. H. (3.7 miles inland)

* Distance inland from exposed open coast

- A-16 A salt marsh on a point of land made by the Hampton River and the first tributary above the Hampton Falls River, Hampton, N. H. (3.5 miles inland)
- A-17 Hampton Landing, Taylor River, Hampton, N. H. (3.01 miles inland)
- A-18 The Willows; at the mouth of Tide Mill Creek and the Hampton River, Hampton, N. H. (1.6 miles inland)
- B- 1 On a small "island" opposite Eastman's Slough and about 2500 feet west of Locke Point State Park area, Hampton Falls, Seabrook, N. H. (1.0 miles inland)
- B- 2 The southernmost portion of Eastman Slough, near Halftide Rock and at the mouth of the Brown River, Hampton Falls-Seabrook, N. H. (1.7 miles inland)
- B- 3 Just inside the mouth of Hunts Island Creek and at the junction of the Brown River, Seabrook, N. H. (1.8 miles inland)
- B- 4 Approximately 500 feet NW of the first tributary past Hunts Island Creek, Hampton Falls-Seabrook, N. H. (2.0 miles inland)
- B- 5 Approximately 700 feet NE of the mouth of Swain's Creek, Hampton Falls, N. H. (2.2 miles inland)
- B- 6 Robbins Point, Hampton Flats, Hampton Falls-Seabrook, N. H. (2.3 miles inland)
- B- 7 Browns River, first tributary upstream from Swain's Creek, Hampton Falls, N. H. (2.5 miles inland)
- B- 8 Approximately 800 feet upstream from Robbins Point, Hampton Falls, N. H. (2.4 miles inland)
- B- 9 Approximately 700 feet upstream from station B-8, Hampton Falls-Seabrook, N. H. (2.53 miles inland)
- B-10 End of Rocks Road, on the Browns River, Hampton Falls-Seabrook, N. H. (2.8 miles inland)
- B-11 Near the mouth of the first major tributary east of the head waters of the Browns River, Hampton Falls-Seabrook, N. H. (3.0 miles inland)
- B-12 Approximately 1500 feet upstream (west) from station B-11, just before a major oxbow, Hampton Falls-Seabrook, N. H. (3.3 miles inland)
- B-13 Swain's Creek, neck of the first oxbow, Hampton Flats, Hampton Falls, N. H. (2.6 miles inland)
- C- 1 At the mouth of the Blackwater River; near the first tributary SW of Mills Point, Seabrook, N. H. (1.5 miles inland)
- C- 2 Approximately 1200 feet SW of the first tributary past Riverside, Seabrook, N. H. (2.2 miles inland)
- C- 3 Approximately 1200 feet south of C-2, Seabrook, N. H. (2.3 miles inland)

- C- 4 Approximately 500 feet SE of C-3, Seabrook, N. H. (2.4 miles inland)
- C- 5 Approximately 800 feet SE of C-4, Seabrook, N. H. (2.5 miles inland)
- C- 6 Approximately 800 feet SE of C-5 and near the first tributary southeast of C-2, Seabrook, N. H. (2.7 miles inland)
- C- 7 Approximately 1200 feet SE of C-6 and near a large white rock, Seabrook, N. H. (3.0 miles inland)
- C- 8 Approximately 1500 feet SE of C-7, Seabrook, N. H. (3.3 miles inland)
- C- 9 By the route 286 bridge which crosses the Blackwater River, Seabrook, N. H. (3.6 miles inland)
- C-10 Mills Point — mouth of the Blackwater River, Seabrook, N. H. (1.3 miles inland)
- C-11 Riverside, Seabrook, N. H. (1.7 miles inland)
- D- 1 At the mouth of the creek between Knowles Island and mainland, Seabrook, N. H. (1.34 miles inland)
- D- 2 Before the first bend near the mouth of Mill Creek, Seabrook, N. H. (1.6 miles inland)
- D- 3 Walton Landing, end of Walton Road, Seabrook, N. H. (2.1 miles inland)
- H- 1 At the junction of the middle piling of the toll bridge in Hampton Harbor and the tower at Hampton, N. H. (0.4 miles inland)
- H- 2 In the channel of Hampton Harbor near the mouth of the Blackwater River and at the junction of the imaginary line between the Seabrook Marina and Knowles Island, Seabrook, N. H. (1.0 miles inland)
- H- 3 Smith and Gilmore Marina, Hampton, N. H. (0.8 miles inland)
- H- 4 Hampton Marina — mouth of Hampton River, Hampton, N. H. (0.97 miles inland)
- HB-Bound
- Rock The area in the immediate vicinity of Beckman's Point, which is near the mouth of Hampton Harbor, Hampton, N. H. Exposed open coast.
- HB-1 A series of offshore rocks in the immediate proximity of the red marker flag, and in 35-40 feet of water, Hampton, N. H. Exposed open coast
- HB-2 The southernmost rock outcrop (a rookery) before the Hampton Breakwater; in 15-20 feet of water and the sheltered side, Hampton, N. H. Exposed open coast.
- HB-3 The exposed (seaward) side of the same rock outcrop as HB-2; 30-40 feet of water, Hampton, N. H. Exposed open coast.
- HB-4 The southernmost outcrop which is opposite the Hampton State Beach Park Breakwater; in 20-25 feet of water, Hampton, N. H. Exposed open coast.

Table II

Surface Water Temperatures and Salinities

<u>Station</u>	<u>Temperature</u> (C)	<u>Salinities</u> (0/00)	<u>Dates*</u>
A1	16 - 20	31 - 33.0	
A2	19 - 19.5	31 - 31.5	
A3	16 - 20.5	31 - 32.0	
A4	19 - 20.8	31 - 32.0	
A5	18 - 21.5	31 - 31.3	
A6	20.5	32.0	
A7	20.5 - 29.5		
A8	15.0 - 19.8	30.5 - 32.0	
A9	(-1.0) - 22.5	20.2 - 30.0	12-21-69
A10	24.0	33.5	
A11	21.5	31.3	
A12	9.0 - 10.0	28.6 - 30.4	10-04-66
A13	8.0	27.4 - 27.6	11-18-66
A14	7.0	24.0	11-18-66
A15	8.0	23.9	11-18-66
A16	9.0	30.6	11-18-66
A17	0.0	24.7 - 24.9	11-13-66
A18	0.0	30.6 - 30.8	11-13-66
B1	16.0	26.3	
B2	17.0 - 18.0	22.8 - 30.9	
B3	17.0 - 19.0	30.5 - 30.9	
B4	16.5	30.5	
B5	16.0 - 16.5	24.4 - 30.3	
B6	2.0 - 17.0	20.7 - 29.9	12-06-69
B7	18.0	28.9	
B8	18.0	28.9	
B9	16.0 - 16.5	17.2 - 18.2	
B10	16.5 - 20.0	16.2 - 31.6	
B11	16.0 - 19.0	14.2 - 30.9	
B12	16.0 - 19.0	13.2 - 30.9	
B13	3.0	28.9	12-06-66
C1	15.0	29.4	
C2	15.5	28.5	
C3	15.5	25.6	
C4	15.0	26.0	
C5	15.5	25.2	
C6	15.5	25.2	
C7	15.5	25.6	

C8	15.5	24.5	
C9	13.2 - 16.2	11.5 - 14.5	10-09-69
C10	10.0	27.2	10-13-66
C11	11.0	26.8	10-22-66
D2	13.0	23.6	11-11-66
D3	13.0	20.2	11-11-66
H1	16.5	30.5	
H2	16.8	30.5	
H4	1.0	30.5	12-21-66
Bound Rock	0.0 - 19.0	29.5 - 32.0	7-18-66

* All dates from August and September, 1969 except those specified.

Table III. Number of Seaweed Taxa of Various Stations

<i>Stations</i>	<i>Total</i>	<i>Chlorophyceae</i>	<i>Phaeophyceae</i>	<i>Rhodophyceae</i>
A1	12	5	3	4
A2	14	7	3	4
A3	11	6	2	3
A4	13	5	3	5
A5	12	5	4	3
A6	5	3	2	—
A7	12	5	4	3
A8	10	4	3	3
A9	11	7	3	1
A10	11	3	3	5
A11	7	2	2	3
A12	7	1	1	5
A13	8	3	3	2
A14	12	2	6	4
A15	8	4	—	4
A16	2	2	—	—
A17	15	4	6	5
A18	8	3	3	2
B1	15	8	5	2
B2	19	8	5	6
B3	13	6	3	4
B4	15	8	3	4
B5	11	5	2	4
B6	19	9	3	7
B7	10	6	2	2
B8	7	4	1	2
B9	11	5	4	2
B10	16	5	6	5

B11	5	2	2	1
B12	7	5	2	—
B13	6	3	3	0
C1	17	7	7	3
C2	13	6	4	3
C3	14	8	4	2
C4	11	6	2	3
C5	19	8	5	6
C6	15	7	5	3
C7	6	4	1	1
C8	1	1	—	—
C9	10	5	2	3
C10	5	2	3	—
C11	11	3	6	2
D1	—	—	—	—
D2	4	—	4	—
D3	6	—	4	2
H1	14	3	5	6
H2	1	—	—	1
H3	18	6	5	7
H4	0	—	—	—
HB-Bound				
Rock	79	23	21	35
HB1	30	3	8	19
HB2	30	1	10	19
HB3	30	0	10	20
HB4	38	4	9	25

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